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Estimating the Yield to Smokers of Tar, Nicotine, and Carbon Monoxide from the 'Lowest Yield' Ventilated Filter-Cigarettes

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Summary

The behavioural misuse of low-yield, ventilated-filter cigarettes is evaluated in two studies. The first reports the results of interviews with 46 low-yield smokers. Fifty-two per cent admitted to having blocked the ventilation holes on these cigarettes at some time with either lips, fingers, or tape. Although only three smokers admitted blocking the holes at the present time, 41 per cent (of the 39 who were observed smoking) gave evidence (by direct observation and by inspection of characteristic stain patterns on the filter) of currently blocking the holes. Study 2 demonstrates, using a modified smoking-machine assay (a 2.4 sec., 47 ml puff, with a 44 sec. interval, vent-holes blocked), how much tar, nicotine, and CO an average smoker might derive from the lowest-yield cigarettes in the U.K., Canada, and the U.S. In comparison to standard assays, tar increases from 15- to 39-fold, nicotine from 8- to 19-fold and CO from 10- to 43-fold. Smokers should be advised of the risks of blocking the holes of ventilated-filter cigarettes and taught how to detect whether they are doing it. The construction of low-yield cigarettes that will ensure low yields to smokers requires careful attention to the behaviour of smokers.

Introduction

Smokers have been urged, *if they are unable to stop smoking*, to smoke low-yield cigarettes [1]. Government-sponsored tar and nicotine assays have been used to guide smokers to presumably less-toxic, low-yield brands [2, 3, 4]. Extremely low-yield brands (< 6 mg tar and 0.6 mg nicotine) usually achieve their reductions of tar, nicotine, and carbon monoxide, in part, by means of one or more rings of air vents on the filters [5, 6]. These vents cause each puff to be diluted with air [7]. Ventilated filter cigarettes are becoming increasingly popular, accounting recently for 15 % of the cigarette market in the U.K. [8], 8 % of the market in Canada (Canadian Tobacco Manufacturers Council, Personal Communication), and 25 % of the market in the U.S. [5].

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A low-yield cigarette is so categorized on the basis of standard smoking-machine assays [9]; however, these machine-smoking yields are poor indicators of human-smoking yields [10–14]. Standard settings for smoking machines underestimate average human smoking behaviour [14], in particular in the case of low-yield cigarettes on which smokers tend to take larger and more frequent puffs than they do on higher-yield cigarettes [15, 16]. In addition, unlike standard smoking-machines, smokers can defeat the purposes of the ventilation holes by blocking them with their fingers or lips [17]. By holding the cigarette farther back in the mouth, smokers can easily occlude almost all the holes with their lips, as effectively as if tape covered them [17].

We report here the results of interviews designed to assess the extent of blocking the holes of ventilated-filter cigarettes, and the results of a modified smoking-machine assay which better estimates the yields of ventilated-filter cigarettes when they are smoked intensively.

Study 1

Subjects and methods

Subjects. Forty-six office workers (7 males, 39 females) who had smoked ventilated-filter cigarettes for at least one month were recruited from four large Toronto businesses. The participants had responded to advertisements requesting interviews with smokers who had used any of 10 Canadian brands of ventilated-filter cigarettes. Ten of the subjects had formerly smoked low-yield cigarettes, but were now smoking higher-yield cigarettes. The entire group had the following characteristics: age, $\bar{X} = 34$, SD = 11.1; number of cigarettes smoked per day, $\bar{X} = 24$, SD = 10.3; number of years smoked, $\bar{X} = 15.4$, SD = 9.1; number of months smoked low-yield, $\bar{X} = 16$, SD = 13.5; number of minutes to first cigarette of the day [18], $\bar{X} = 65.7$, SD = 59.4.

Interviews. The interviews were conducted individually in a quiet, private room at the participant's workplace. The interviewer, posing as a cigarette smoker, stressed the non-threatening nature of the interview. Before questioning about the ventilation-holes, the interviewer asked the participant to smoke one of the low-yield cigarettes, ostensibly so that questions could be asked about the cigarettes while they were being smoked. The interviewer observed whether the smoker was occluding the ventilation holes to any extent with fingers or lips. Next, the interviewer asked a series of questions about hole-blocking and about reasons for smoking a low-yield brand.*

Inspection of spent filters. If the holes have not been blocked on a vented-filter, the tar stains on the proximal end of the filter will show as a discrete dark area in the center with a ring of unstained filter around the periphery, since air has been drawn in through the vents and takes the place of smoke in the periphery of the filter. If the holes have been blocked fully, a uniform field of stain is found on the proximal end of the filter, since smoke and not air has passed through the periphery as well as the

*Copies of the interview schedule are available from L.T.K.

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center of the filter [17]. The spent filters were sorted into 3 classes (probably not blocked, partially blocked but unable to be confident if due to behavioural factors, and probably blocked fully), according to the stain pattern on the filter [19].

Results and Discussion

Reasons given for smoking low-yield cigarettes. Ninety-four per cent of the responses depended on the assumption that these cigarettes actually delivered low-yields to smokers: these cigarettes were said to be safer, milder, less likely to produce physical symptoms, and the first step in quitting.

Self-reported hole-blocking. Fifty-two per cent of the smokers (± 14 %, 95 % confidence interval) reported that, when they first began smoking these cigarettes, they had blocked the holes with either fingers (39%), lips (20%), or tape (20%). Only 3 of the 36 current low-yield smokers said that they currently blocked holes; two of these smokers said that they used their lips to block the holes; one reported to use fingers.

Direct observation of hole-blocking. Thirty-nine (35 current, 4 former) low-yield smokers agreed to smoke a ventilated-filter cigarette during the interview. Forty-four per cent (± 16 %) were observed to block the holes to some extent with either fingers (15 %) or lips (28 %). Five of the thirty-three females left unmistakable signs of blocking the holes with their lips – lipstick stains over the perforations.

Indirect observation of hole-blocking. The stain-patterns on the butts were sorted as follows: 4 % were probably not blocked, 44 % appeared partially blocked but were impossible to judge with any confidence, and 15 % were probably blocked very effectively.

Both measures together. In 21 of 22 cases in which the direct and indirect observation made a distinct indication (yes or no), there was concordance between the two measures; one observation of blocking was not confirmed by a stain pattern. Forty-one per cent of the smokers gave both direct and indirect evidence of hole-blocking.

Awareness of hole-blocking. Of the 91 % of the current low-yield smokers who smoked during the interview and who said that they did not now block the holes, 38 % appeared to be blocking the holes (by both indirect and direct criteria). If most participants were not being deceptive, this finding suggests that smokers can develop an unwitting habit of blocking the holes. If this is so, it is less surprising to encounter hole-blockers who still believe that they are deriving low yields from their vented cigarettes.

Hole-blocking and tobacco dependence. Smokers who are more dependent on tobacco seem to need to smoke shortly after they wake up in the morning, presumably to increase their blood nicotine to an accustomed level [18]. Hole-blockers were hypothesised to be more dependent on nicotine than were non-blockers. In support of this hypothesis, the 6 participants who gave evidence of being very effective

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hole-blockers (i.e. they used their lips to block the holes) reported that they took 20 minutes (SD = 17) to have their first cigarette of the day, while the 13 subjects who gave no indication at all of being hole-blockers took 60 minutes (SD = 50, $t(17) = 2.61, p < .05$). The average daily cigarette intake of the blockers ($\bar{X} = 23$, SD = 7.5) and non-blockers ($\bar{X} = 27$, SD = 7.8) did not differ significantly.

A comment on the percentages. Our sample was not drawn at random and our measurement techniques are open to error. At the least, however, this survey is a collection of case studies of an important type of misuse of vented cigarettes; and, at most, it gives an approximate idea of how widespread the problem may be. Although one might be uneasy about the objectivity of the motivated interviewer who observed the hole-blocking, one can rely on the testimony of a cigarette butt which bears the characteristic pattern of tar deposits [17] as well as a ring of lipstick centered over the holes.

Study 2

Hole-blockers, and some researchers, may not realise the implications of hole-blocking for the tar, nicotine, and carbon monoxide yields of cigarettes. Some individuals have said to us, 'It doesn't really make that much difference, does it? Aren't these low-yield brands made of milder tobacco? How is it possible to get high doses of tar and nicotine from them?' The second study was designed to answer these questions, by means of an adjusted smoking-machine assay of the yields of the lowest or close to lowest-yield cigarettes in three countries.

Materials and methods

Table I lists the brands and their country of manufacture. Thirty cigarettes of each brand were assayed for tar, nicotine, and CO under each of two smoking-machine conditions: Standard and Behavioural. All cigarettes were conditioned for 48 hr at 22 °C and 60 % relative humidity.

Standard Condition. Standard international parameters were used: 35 ml puff volume, 2 sec. puff duration, and 58 sec. puff interval; butt length was filter-plus-overwrap plus 3 mm.

Behavioural Condition. These settings were based on observations which had been made as part of the ongoing research program on Smoking and Health at Labstat Incorporated. Forty-eight smokers had been video-taped individually while they smoked one of the cigarettes in Table I (Medallion KSF). Analysis of the resulting tapes provided the following values: 44 sec. puff interval (SEM = 2.7) and 2.4 sec. puff duration (SEM = .12). Estimates of puff volume were not obtained from our group of subjects, but a value of 47 ml was chosen since this is the maximum obtainable from the 50 ml syringe which governs the puff volume of most commercially-available smoking machines. This value is likely to underestimate the average smoker's puff-volume by 2 to 13 ml [20–22]. Vent holes were blocked fully by means of a small piece of tape.

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Table I A Cpmparison of Cigarette Yields under Standard (A) and Behavioural (B) Conditions for Six 'Less Hazardous' Brands[1]

Brand name and Nationality	Filter Length (mm)	No of Puffs		Tar (mg)[2]		Nicotine (mg)[2]		Co (mg)[2]	
		A	B	A	B	A	B	A	B
United Kingdom									
John Player King Size Ultra Mild	23	10.6	10.6	0.8	28.5	0.12	2.24	0.5	21.4
Silk Cut Ultra Mild with Substitute KSF[3]	29	9.9	8.6	0.8	15.5	0.15	1.46	0.9	17.5
Embassy Ultra Mild KSF	27	8.4	7.9	0.8	22.3	0.12	1.70	0.7	18.5
Canadian									
Medallion KSF	30	10.3	8.6	0.7	15.0	0.10	1.13	1.5	23.9
Viscount No. 1 KSF	30	10.1	8.6	0.3	11.7	0.03	0.56	0.9	21.8
Monitor E KSF[4]	21	8.2	9.2	13.7	20.1	0.95	1.29	16.8	22.8
American									
Cambridge KSF	32	10.5	7.1	0.8	11.7	0.10	0.82	1.8	17.5

[1]Standard Condition (A); puff duration, 2 sec.; puff interval, 58 sec.; puff volume, 35 ml; and Behavioural Condition (B); 2.4 sec.; 44 sec.; 47 ml respectively. See text for additional details.
[2]Average standard errors of the mean under 'behavioural' condition were puffs, 0.14; tar, 0.5 mg; nicotine, 0.03 mg; and CO, 0.40 mg.
[3]KSF, King Size Filter. All brands had perforated filters (air dilution devices).
[4]An unventilated-filter 'control' cigarette whose characteristics are similar to those of the average Canadian cigarette.

Results and discussion

The Behavioural Condition (B) causes a dramatic increase in yields over the Standard Condition (A) (see Table I): tar levels increase 15- to 39-fold, nicotine levels increase 8- to 19-fold, and carbon monoxide increases 10- to 43-fold. The Behavioural Condition converts John Player King Size Ultra Mild to cigarettes which would fall into the High-tar category, according to the most recent British League Table. The Behavioural Condition converts the lowest-yield Canadian cigarettes to 'average' yield cigarettes (see results for Monitor E in Table I). The results of the Behavioural Condition are not precisely predictable from the results of the Standard Condition. Five cigarette brands have almost identical standard tar yields (0.7 or 0.8 mg), but under the Behavioural Condition they differ by close to a factor of 3.

Low-yield brands may achieve their reduced yields by any or all of several design strategies (e.g. high-retention filters, high porosity papers, vented filters, low tar/nicotine tobaccos, and non-tobacco additives such as New Smoking Material). Thus, it is not surprising that blocking vents does not affect the yields of Silk Cut Ultra Mild with Substitute (with 40 % New Smoking Material) as much as it does the yields of an 'all tobacco' cigarette such as John Player King Size Ultra Mild.

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Ventilation techniques provide the only practical ways of reducing CO yields at the same time as tar and nicotine yields are reduced. Hole-blocking may help explain the finding that ventilated-filter cigarettes deliver more carbon monoxide to smokers than would be expected from the standard smoking-machine assays [12, 23].

Yields per puff. Since neither the Standard nor the Behavioural Condition requires that a fixed number of puffs be taken on the cigarettes, a comparison of brands based on total yields alone may be misleading [11, 12]. For example, in the Behavioural Condition, John Players King Size Ultra Mild are 28% higher in tar than are Embassy Ultra Mild, yet on a per-puff basis, Players are 5% lower in tar. The number of puffs taken on a cigarette during any smoking machine assay must be reported [12], so that needed adjustments can be made when comparing the yields of different brands.

General discussion

The Behavioural Condition used here is conservative. Some authorities have suggested a Behavioural Condition assay which is based on the 95th percentile of smoking parameters found in heavy smokers who smoke low-yield cigarettes [24].

Since in this study, over one-third of the smokers of ventilated-filter cigarettes appear to block the holes, many unknowingly, smokers of this type of cigarette should be warned of the risks of such a manoeuvre and advised to inspect their spent filters to see whether they block the holes.

Although this report has emphasized extremely low-yield ventilated-filter cigarettes, air dilution filters are being used on moderate-yield cigarettes as well. Most ventilated brands have obvious holes on the filters, but recent technological advances make it possible to produce ventilation effects by means of porous filter plug wraps and 'invisible' electrostatic perforations. Public health concerns should dictate that all ventilation-holes should be clearly visible, so that a would-be lower-yield smoker can see to avoid the perforations.

The design of a cigarette which will deliver low yields to smokers will require careful attention to the behavioural adaptations available to the smoker.

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